

Development of a Nonfat Drinkable Yogurt for the Cal Poly Creamery

A Senior Project

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ABSTRACT

The objective of this experiment was to develop a prototype drinking style yogurt for the Cal Poly Creamery.

Originating in the Middle East, yogurt has become a cornerstone product in the dairy market worldwide. Due to the natural active cultures that exist within yogurt, the consumer receives physiological benefits from eating this delicious dairy product. Yogurt is unique in that it comes in various flavors, consistencies, and textures; likewise the industry is unique as well, as there exists countless different processing techniques to make new and innovative yogurt products. Consumers cite the texture and flavor of the yogurt as the most important attributes affecting their purchasing decisions. In this project two different types of yogurt were processed using gelatin or pectin as stabilizers on two separate occasions with and without packaging through a wire bell smoothening device. The finished yogurts were G, G/S, P and P/S – representing gelatin with no smoothening, gelatin with smoothening, pectin with no smoothening and pectin with smoothening. The pH of the yogurt was monitored every 30 minutes during fermentation. Stabilizer type did not affect pH development of yogurt. Sensory evaluation of the yogurts revealed that the order of preference were ~40%, 35%, 15% and 10% respectively for yogurts G, P/S, G/S and P. This suggests that gelatin was most preferred and when pectin is used as stabilizer, processing through a smoothening device is desirable.

INTRODUCTION

Over the past few decades, the food market has undergone drastic changes. No longer is the consumer simply looking for a product with quality taste; rather, the average consumer hopes to receive brand security, taste, and nutritional value in their products. Yogurt is one of the few foods that fulfills all these requirements for consumers. One of the most important features of yogurt is its role as a delivery vehicle for probiotics and nutrition. According to the International Dairy Foods Association, “yogurt sales have increased every year since the early 1990’s.” This is showcased by the amount of yogurt produced in 2011, as 3.7% of all milk was utilized for cultured dairy products. A main reason yogurt has been able to hold such a large portion of the market is the variety it offers. There are many different types of yogurt—Greek, stirred, set, and fluid—each with their own different processing techniques that appease a wide array of consumers. The Cal Poly Creamery is consistently looking for new methods to maximize its production of dairy products. An effective means for the creamery to expand and ensure the entirety of its milk stock is utilized would be to create its own line of yogurt. A nonfat, label friendly, drinking style yogurt would appeal to the well to average college consumer, providing a new profit stream for the Cal Poly Creamery.

The objective of this experiment was to develop a prototype drinking style yogurt for the Cal Poly Creamery.

LITERATURE REVIEW

Yogurt originated centuries ago in the Middle East and is now a widely consumed dairy product all throughout the world (Robinson and Tamime, 1975). According to the Code of Federal Regulations (CFR 131.200) yogurt can be defined as, “Yogurt is the food produced by culturing one or more optional dairy ingredients with a characterizing bacterial culture that contains the lactic acid-producing bacteria, *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. One or more other optional ingredients may be added, but must be added prior to culturing. Yogurt, before the addition of bulky flavors, contains not less than 3.25 percent milkfat and not less than 8.25 % milk solids non fat, and a titratable acidity of not less than 0.9%, expressed as lactic acid. The food (base) may be homogenized and shall be pasteurized or ultra-pasteurized prior to the addition of the bacterial culture. Flavoring ingredients may be added after pasteurization or ultra-pasteurization. To extend the shelf life of the food, yogurt may be heat treated after culturing is completed, to destroy viable microorganisms.” By consuming yogurt one does not only obtain the satisfaction of flavor from this dairy food, but there are also health benefits. The consumer physiologically benefits from eating yogurt because it is well known that there are several peptide sequences that are within the milk proteins that provide health benefits to the customer (Ramchandran and Shah , 2008). Moreover, full fat yogurt also contains all the essential nutrients in milk as well as a high concentrations of β -carotene, calcium and phosphorous which the body needs. It has been discovered that by consuming yogurt there is a correlation to the reduction of serum cholesterol, immunocompetence and anticarcinogenic effects to the human body (Vedamuthu,1992). Yogurt is made by lactic acid bacteria through the fermentation of milk to $\text{pH} \leq 4.6$ (Lee and Lucey, 2006).

Types of Yogurt

There are many distinct styles of yogurt including Greek, stirred, drinking (fluid), and set yogurts. All of these different types vary in their manufacture and are created through different processing techniques. “Yogurt may be defined as the solid, custard-like fermented milk product made from fortified high-solids milk using a symbiotic mixture of *Streptococcus salivarius* subsp. *thermophilus* (coccus) and *Lactobacillus delbrueckii* subsp. *bulgaricus* (rod) as starters.. Additionally, the regulations specify that yogurt before addition of bulky flavors contains not less than 3.25% milk fat and not less than 8.25% milk solids-non-fat and has a titratable acidity not less than 0.9%” (Vedamuthu, 1992). Formulations vary from each style of yogurt depending on what attributes the producer is trying to establish for consumer acceptance. For instance there are many different styles of yogurt, they could be set and thick, or smooth and viscous, or liquid and free flowing. According to Soukoulus et al., (2007) the texture and flavor of yogurts are the most important considerations determining consumer acceptance. In order to achieve a yogurt of the greatest quality, texture and firmness of the yogurt without syneresis is key (Jumah et al., 2001). Although each different type of yogurt gives different characteristics, the basic formula for creating today’s yogurt includes the preliminary treatment of milk, homogenization, pasteurization, cooling the product to incubation temperature, inoculating with a starter culture, incubating until the desired pH of 4.4-4.6 is reached, breaking the coagulum, and lastly flavor addition and packaging.

Processing Steps

According to Soukoulis et al., (2007) the heat treatment of milk for producing yogurt is crucial for proper texture development. The proper heat treatment ranging from 80 to 85°C for 30 min to 90 to 95°C for 5 min causes whey protein denaturation which allows the whey proteins to accompany with the casein micelles and produce water binding properties which are necessary

for the manufacture of yogurt. This is a crucial step because without the ideal heat treatment temperature it will result in syneresis (wheying-off) which is unsatisfactory to the average consumer. The processing step of homogenization when incorporated with heat treatment results in the best end product with regards to quality and consumer acceptance (Robinson and Tamime, 1975). The manufacturing step of the incubation time and temperature is also of great importance in correlation to heat treatment. As noted in a study by Lee and Lucey (2006), increasing heating temperature and decreasing incubation temperature accounted for oral viscosity and mouth coating while by decreasing heating temperatures and increasing incubation temperature results in a larger visual particle size and lower smoothness in yogurts. Since the heat treatment applied to the yogurt manufacturing process (pasteurization) influences both the incubation time and acidification rate, reducing the incubation time is caused by whey protein denaturation (Soukoulis et al., 2007). By altering incubation and preheating temperatures it is possible to manufacture yogurt with the sensory and physical characteristics desired by the consumer. According to Ashton (1963) the temperature of the cultured mix after bottling and the incubation temperature should be the same. The ideal incubation temperature is 41-42°C and should not surmount 49°C however, for viscous type yogurt the incubation temperature can range from 21-38°C (Ashton, 1963). The incubation is also influenced by the milk fat content of the yogurt. Yogurts made using skim milk had much lower incubation rates but also resulted in greater viscosity and lactic acid concentrations according to tests Soukoulis et al. (2007). The composition of the milk greatly influences not only the nutritional value of the product but also the coagulum of the product (Robinson and Tamime, 1975). The basic medium for yogurt can be whole milk, dried milk, evaporated milk, skimmed milk, and partially skimmed milk (Ashton, 1963). All of these media result in different end products in regards their rheological properties,

texture, flavor, and nutritional value. Since the physical and rheological properties are of the utmost importance to consumers the use of fortification can greatly improve the rheological properties of yogurt. In yogurts that have not been fortified common quality issues include poor texture, weak body, syneresis and variation in consistency (Peng et al., 2009). The most common materials used for fortifying yogurt include whey protein concentrates, milk protein concentrates, caseinates, and skim milk powder (nonfat dry milk) (Soukoulis et al., 2007). Milk protein fortification results in a firmer body and less whey separation in yogurts (Peng et al., 2009). The fortification of the milk solid content often increases the incubation time of yogurt. Soukoulis et al. (2007) reported that the incubation time of yogurt was significantly increased when whole milk was substituted with skim milk ($P \leq 0.001$). It was also reported that skim yogurts had greater firmness than whole fat yogurts and sensory evaluation concluded that the use of skim milk greatly improved viscosity, acidity, texture, and sensory attributes and overall flavor (Soukoulis et al., 2007).

Starter Cultures

As compared with heating temperatures, incubation time and temperatures, and fortification, the starter cultures used in manufacturing yogurt is of the utmost importance. Fat substitutes are frequently added to yogurt mix in order to minimize the textural defects of low-fat and fat free yogurts (Robitaille et al., 2008). The use of stabilizers in yogurt is illegal in some countries due to consumer awareness and the desire for natural products (Amatayakul et al., 2006). An alternative to adding fat substitutes to the milk would be using starter cultures that produce exopolysaccharides (EPS). Exopolysaccharides occur in two forms rropy which are excreted into the environment, and capsular which remains attached to the bacterial cell surface (Amatayakul et al., 2006). Both forms have been known to reduce syneresis which is a main

defect of yogurt. The use of EPS producing starter cultures stimulates water binding properties which in turn result in improved firmness, texture, and viscosity, while also minimizing physical and thermal shock of the yogurt (Ramchandran and Shah , 2008) According to Robitaille et al. (2008) for the manufacture of yogurt the starter culture must contain at least one *Streptococcus thermophilus* strain and *Lactobacillus delbrueckii* ssp. *bulgaricus* strain. The *Lb. bulgaricus* is added for its properties of promoting the acidification process while also improving the organoleptic qualities of the end product. According to (Vedamuthu, 1992). *Lb. bulgaricus* is a rod-shaped bacterium that is quite heat-tolerant and also has a complex enzyme system that allows it to break down lactose well. Using a starter culture with lacto bacillus strains that produce EPS result in a yogurt that is heavy and smooth in body Vedamuthu (1992). *Lb. bulgaricus* promotes EPS production while the combination between both cultures produces an increase in EPS. *S. thermophilus* takes a minor part in the proteolysis during the milks fermentation, making it a smart choice for a starter culture for most producers (Robitaille et al., 2008). *S. thermophilus* are spherical in structure and are also heat-resistant. *S. thermophilus* produce yogurts with a smooth viscous body and because of the EPS production help embody the consistency of the texture and the coagulum (Vedamuthu, 1992).

Stabilizers

Although many countries do not allow the addition of stabilizers in their yogurt, some countries still allow stabilizers to be supplemented within their yogurt. The chosen stabilizers frequently dictate the overall texture within the final product (Schmidt et al., 2001). Stabilizers are also used in yogurt to increase viscosity, improve consistency, and reduce syneresis. Common stabilizers used include starch, alginate, carrageenan, derivatives of methylcellulose, gum Arabic, tragacanth, karaya, locust bean gum, gelatin and pectin (Everett and McLeod, 2005). Stabilizers

increase viscosity and firmness of yogurt. Hydrocolloids function with their ability to bind water, react with the milk constituents, stabilize the protein network, prevents free movement of water, and prevents syneresis (Soukoulis et al., 2007). Gelatin and pectin are the most preferable stabilizers for use in fermented milks (Soukoulis et al., 2007, Dickinson et al., 1998). According to Clark et al., (2009), gelatin is defined as, “a protein that is derived from the partial hydrolysis of skin, bones, and connective tissues from cattle, pigs, and selective fish. Gelatin is not only compatible with yogurt but also a wide variety of ingredients and foods. Melt-in-mouth is perhaps the most preferred attribute that gelatin encompasses (Harris, 1993) The only downside to using gelatin as a stabilizer would be for consumers who choose to not consume products derived from animals. For vegan consumers, pectin is a wise alternative. Pectin is derived from the wastes of processed fruit products (Madhav et al., 2002) this would appeal to customers who are trying to avoid products that contain animal byproducts. In an experiment by Ramaswamy and Basak (1992) it was noted that when 0.3 and 0.4% pectin was added the rheological profile of flavored yogurt was improved (Soukoulis et al., 2007)

Yogurt Consumption Trends

The yogurt industry has a definite impact on the U. S economy; with the mass acceptance of yogurt throughout the U.S. it has even been approved as a meat alternative within the U.S’s public education school lunch program. Over the last 20 years yogurt consumption has been increasing steadily which can be attributed to the consumer’s preference for a product that is both nutritious and beneficial to the consumer (Schmidt et al., 2001). According to Dairy Facts (2012 Edition), “Yogurt sales have increased every year since the early 1990’s. Sales for 2011 set another record at 4.3 billion pounds, an increase of 2.2% over 2010 levels.” This solidifies the

fact that yogurt consumption is only increasing and will continue to increase because of its nutritious quality, health benefits, and consumer acceptance.

Senior Project Research Objectives- to produce two different yogurt products using gelatin as a stabilizer for the first and pectin for the second and also determine the consumer preference of each product.

MATERIALS AND METHODS

A list of ingredients and processing equipment used for yogurt manufacture are given below:

Ingredients/Materials

Pasteurized Skim Milk

Nonfat dry milk (NFDM) (DFA, Fresno, CA)

Mono-diglyceride

Sodium Citrate (ADM, Decatur, IL)

Gelatin (PB, Leiner)

Potassium Sorbate (Quihe, China)

Pectin (Tic Gums, MD)

Yoflex mild 1.0 (CHR Hansen, Inc., Milwaukee, WI)

Piston Filler (flowmaster)

CEM microwave oven,

turbon mixer filler

DPTC processing tanks

Beckman pH meter

Methods

Drinking Yogurt Mix

Two different batches (1 and 2) of yogurt mixes were made using the same ingredients except pectin was used in one batch and gelatin in the second batch. Ten (10) gallons of commercial pasteurized and homogenized milk (Producers Dairy) was standardized to 20.22 solids content by blending 371 g of NFDM (Dairy America Fresno, CA.), 8.14 lbs of sugar, 55 g gelatin, 51 g mono-diglyceride, 20 g sodium citrate (Archer Daniels Decatur, IL), 0.09 g potassium sorbate (Quihe, China). In batch 1 0.55 g of Pectin was used and in batch number 2 0.55 g of gelatin. Both mixes were blended for 10 min using the Scott Turbon Mixer (Scott Turbon Mixer, Inc, Adelanto, CA) and heat treated using HTST within the DPTC processing unit using extended holding tubes at 85°C for 2 min and homogenized at 13790 kPa 1st stage and 3447 kPa 2nd stage. The pasteurized and homogenized mixes were collected into separate processing tanks and cooled to 43°C. Then, each mix was inoculated with 10 g of Yoflex mild 1.0 (CHR Hansen, Inc., Milwaukee, WI) and agitated for 3 min. The pH of each batch was monitored every 30 min until a final pH of 4.6 was reached at approximately 4 ½ hr. Upon reaching a pH of 4.6 the coagulum was broken within the processing tank by gentle surface scrape mixing and simultaneous cooling to 4-10°C to form a flowable drinking yogurt. This procedure was done in duplicate.

Filling of drinking yogurt

Once the coagulum was broken the product was then filled using the DPTC piston filler (flowmaster) twenty bottles of each batch of yogurt blends were filled into 946 ml containers. Then ten bottles were filled without using the wire bell smoothing device. Upon filling the first 10 bottles the wire bell smoothing device was placed on the discharge side of the piston filler and 10 more bottles were filled. After filling a total of 40 bottles the final product was placed in the milk cooler room at the DPTC for cold storage. This procedure was done in duplicate.

Solids Testing

Upon first blending batches 1 and 2, a solids test was conducted using the CEM Microwave oven. 3 ml of both batch mixture 1 and 2 were placed inside a two separate falcon tubes. The tubes were then taken to the CEM Microwave oven. After standardizing the CEM to take a solid content of yogurt mix, 3 ml of batch 1 mixture was sandwiched between two CEM square sample pads and inverted within the CEM. The total solids content were 20.22% for batch 1 and, 18.68% for batch 2. This procedure was done for both experiments resulting in total solids of 19.29 for batch 1 and 19.69 for batch 2 experiment 2.

Sensory Evaluation

Upon completion of each experiment, sensory evaluations were completed and results of these evaluations were compared. Each variable of the final product was randomized within the sensory evaluation under the following system: gelatin without the smoothing device(G), gelatin with the smoothing device (G/S), pectin with the smoothing device(P/S), and pectin without the smoothing device(P); each of these variables were then randomly assigned a letter from A to D. In order to ensure the elimination of any biases, the letters for each variable varied from sensory evaluation 1 to evaluation 2. The procedures in conducting sensory evaluations 1 and 2 were exactly the same, the only difference being the letter assigned to each variable. Participants for the sensory evaluations were Cal Poly students enrolled in DSCI 461. Each participant was asked to taste and evaluate the 4 yogurt products and rate them on the following attributes: texture, mouth-feel, smoothness, and flavor on a 4 point degree of liking scale with 1 being the most desirable flavor and 4 being the least. Upon completion of both sensory evaluations, the ranking scores for each product were averaged and trends were analyzed.

pH Monitoring

Using the Beckman pH meter the pH of both products for both experiments were monitored every 30 mins. The pH meter was standardized before each reading.

RESULTS AND DISCUSSION

pH

The pH of the both yogurts were monitored every 30 min. As shown on tables 1 and 2, there was no significant difference between the two. Experiment 1 took 4.5 hrs to reach a pH of 4.6 while experiment 2 only took 4 hrs to reach a pH of 4.6.

Figure 1. Experiment 1 product pH over 4.5 hours

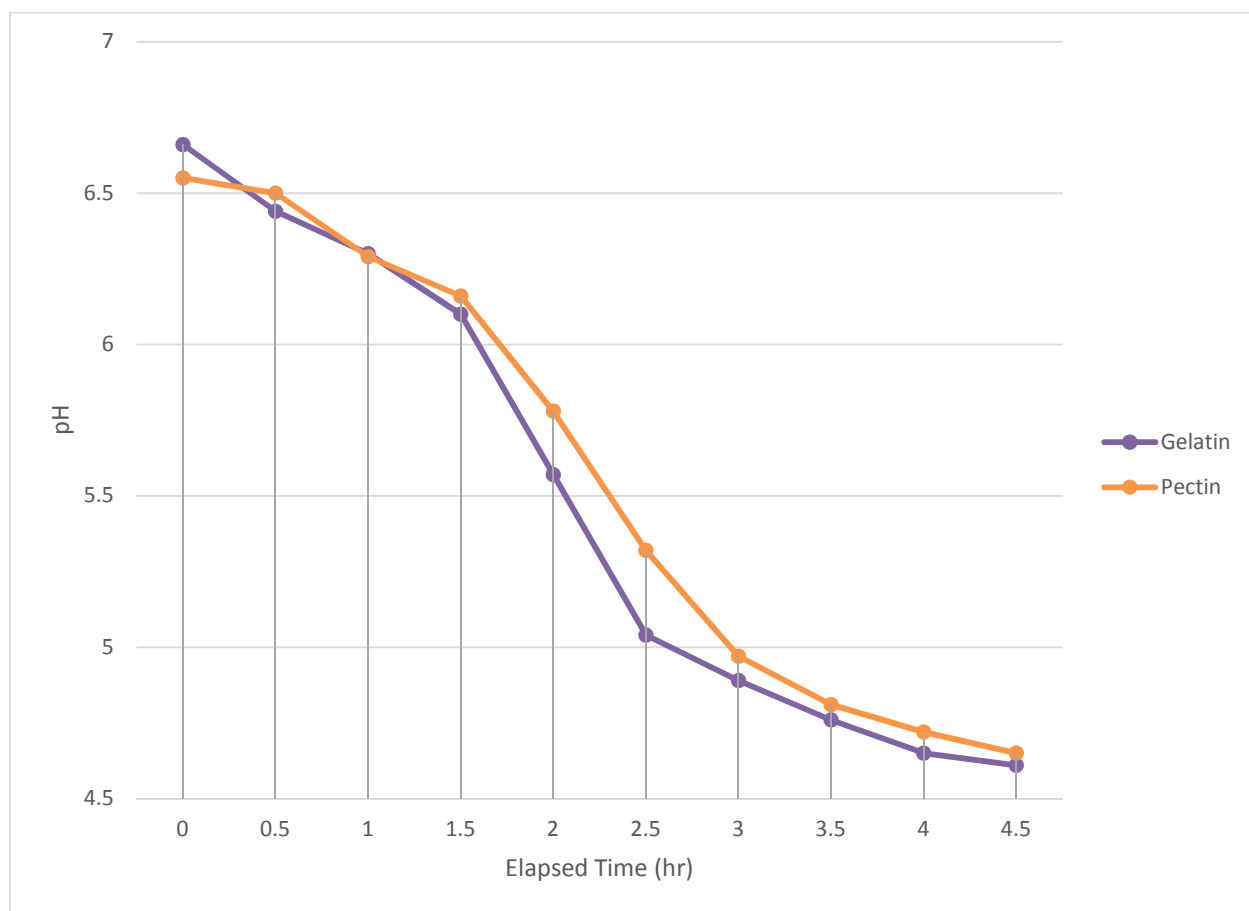
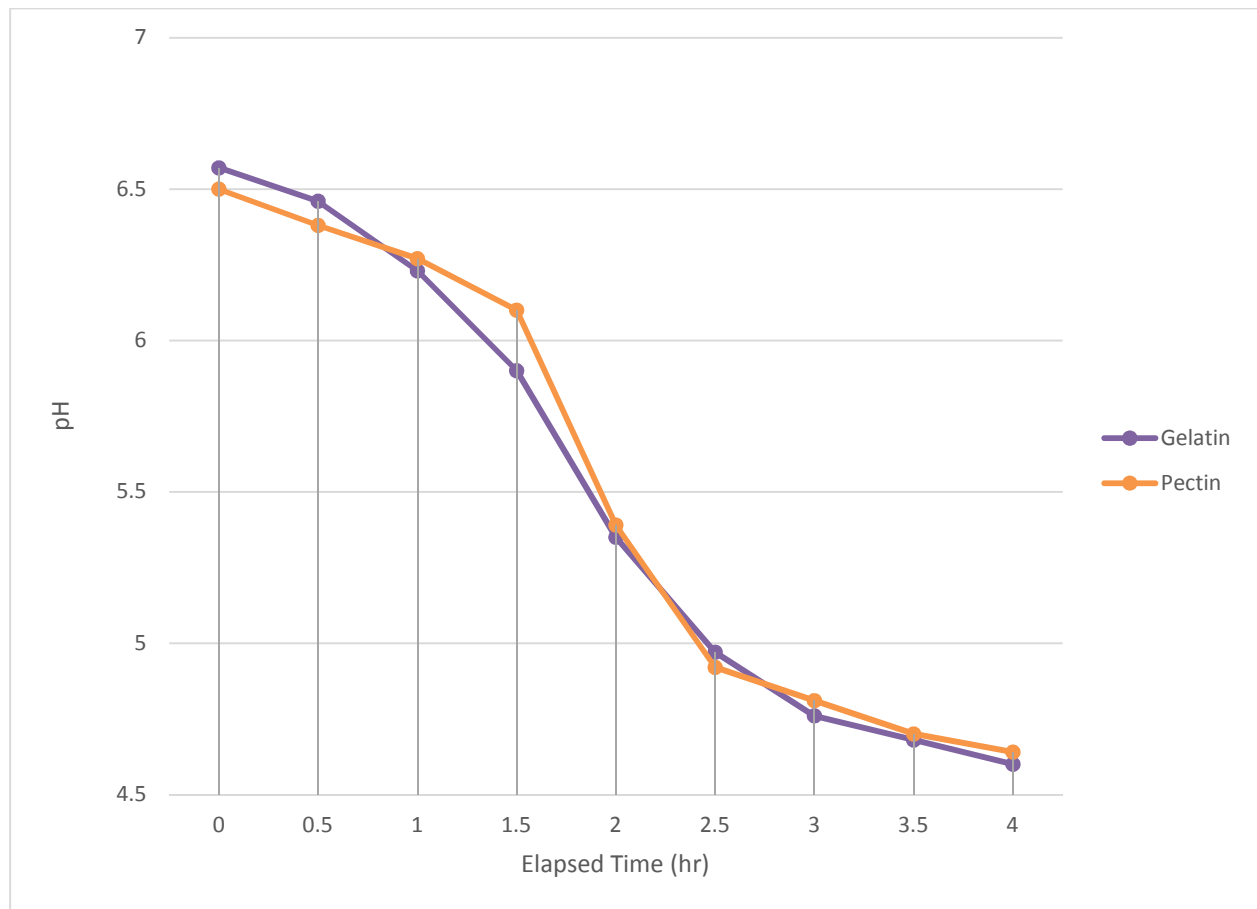


Figure 2.Experiment 2 pH over 4 hrs



Sensory evaluation

An untrained panel of 20 students from DSCI 461 was asked to rate the 4 types yogurts on the following attributes: mouthfeel, texture, smoothness, and flavor. These attributes were being examined for the following yogurt products: gelatin (G), gelatin with smoothing device (G/S), pectin (P), and pectin with the smoothing device (P/S). Each panelist was asked to compare and contrast each of the attributes and rate each on a 4 point degree of liking scale with 1 being the

most desirable product and 4 being the least. This sensory evaluation was done in duplicate. In the tables below the average score for each attribute was totaled.

Mouthfeel- Upon tallying up the total likings for the mouthfeel attribute, the percentage of tasters who preferred yogurt made with gelatin alone was 40%. The percentage of tasters who liked yogurt made with pectin with the smoothing device was 35% while 15% liked yogurt made with gelatin and processed with the smoothing device and 10% liked yogurt made using pectin alone as stabilizer.

Texture- Upon tallying up the total likings for the texture attribute, the percentage of tasters who preferred yogurt made with gelatin alone was 43%. The percentage of tasters who liked yogurt made with pectin with the smoothing device was 33% while 13% of tasters equally preferred both yogurt made with gelatin and processed with the smoothing device and yogurt made using pectin alone as a stabilizer.

Smoothness- Upon tallying up the total likings for the smoothness attribute, the percentage of tasters who preferred yogurt made with pectin with the implemented smoothing device was 40%. The percentage of tasters who preferred gelatin alone was 35% while 18% preferred yogurt made with gelatin and processed with the smoothing device and 0.8% liked yogurt made using pectin alone as stabilizer.

Flavor- Upon tallying up the total likings for the flavor attribute, the percentage of tasters who preferred yogurt made with gelatin alone was 45%. The percentage of tasters who liked yogurt made with pectin with the smoothing device was 30% while 8% liked yogurt made with pectin

alone and 5% of tasters preferred yogurt made with gelatin and processed with the smoothing device.

The tables below show the sensory scores for the following attributes of the different yogurt containing gelatin (G) or pectin (P) and processed with smoothening device in line (G/S or P/S).

Table 1. Number of sensory panelists liking mouthfeel of different yogurt types

Product	Sensory 1	Sensory 2	Total
G	9	7	16
G/S	1	5	6
P	1	3	4
P/S	9	5	14

Table 2. Number of sensory panelists liking texture of different yogurt types

Product	Sensory 1	Sensory 2	Total
G	7	10	17
G/S	2	3	5
P	4	1	5
P/S	6	7	13

Table 3. Number of panelists who liked smoothness of different yogurts types

Product	Sensory 1	Sensory 2	Total
G	7	7	14
G/S	4	3	7
P	3	0	3
P/S	5	11	16

Table 4. Number of sensory panelists who liked flavor of different yogurt types

Product	Sensory 1	Sensory 2	Total
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G	9	9	18
G/S	2	4	6
P	3	1	4
P/S	5	7	12

CONCLUSION

With the assistance of the 20 untrained panelists, the researcher was able to collect two sensory evaluations for each of the 4 different types of yogurt. The results of these sensory evaluations revealed that the yogurt made using gelatin as the stabilizer and without using the bell curve smoothing device was the preferred yogurt amongst consumers. Yogurt made using gelatin without the smoothing device had a preference ranking of 40% for mouthfeel, 45% for flavor, and 43% for texture, and 35% for smoothness. The yogurt made using pectin as a stabilizer while utilizing the implemented smoothing device was the second most preferential to gelatin. However, this pectin yogurt did surpass the gelatin competitor in consumers' preference towards smoothness at 40% likeability. These results are significant because they prove that gelatin is be the preferred stabilizing agent among the common consumer when rating the yogurt on the attributes of texture, flavor, smoothness, and mouthfeel when the wirebell smoothing device was not used.

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